

What is claimed is:

1. A chirped pulse amplification system comprising, a nonlinearly chirped fiber Bragg grating pulse stretcher system, said fiber Bragg grating pulse stretcher system producing stretched pulses longer than 300ps; at least one amplifier following said stretcher system, and a pulse compressor for compressing said stretched pulses by more than a factor of 50.
2. A chirped pulse amplification system comprising, a nonlinearly chirped fiber Bragg grating pulse stretcher system, said fiber Bragg grating pulse stretcher system producing stretched pulses longer than 1 ns; at least one amplifier following said stretcher system, and a pulse compressor for compressing said stretched pulses by more than a factor of 150.
3. A chirped pulse amplification system comprising, a nonlinearly chirped fiber Bragg grating pulse stretcher system, said fiber Bragg grating pulse stretcher system producing stretched pulses longer than 100 ps; at least one amplifier following said stretcher system, and a pulse compressor for compressing said stretched pulses by more than a factor of 50.
4. A chirped pulse amplification system according to claim 3, wherein said amplifier comprises one of a bulk amplifier, a fiber amplifier, a diode laser amplifier, a parametric amplifier, a Raman amplifier or a combination thereof.
5. A chirped pulse amplification system as in claim 3, wherein said fiber Bragg grating pulse stretcher system includes plural concatenated fiber Bragg grating stretchers.

6. A chirped pulse amplification system as in claim 3, wherein said pulse compressor comprises at least one fiber Bragg grating compressor and a bulk grating compressor.
7. A chirped pulse amplification system as in claim 3, wherein optimally compressed pulses are obtained at a target downstream from said pulse compressor, where the optical beam-path between said pulse compressor and said target further contains additional optical elements other than air.
8. A chirped pulse amplification system as in claim 7, wherein said additional optical elements comprise optical beam delivery fibers.
9. A chirped pulse amplification system as in claim 8, wherein said delivery fiber comprises one of a single-mode fiber, a multi-mode fiber operated with a single-mode output, a hollow fiber, a photonic crystal fiber, and a fiber with a guiding air-hole core.
10. A chirped pulse amplification system, comprising; a seed pulse source producing short optical pulses with a certain spectral bandwidth; a chirped fiber Bragg grating stretcher, said fiber Bragg grating stretcher exhibiting a group delay ripple of less than 10 ps within the spectral bandwidth of said seed pulse source; an amplifier following said stretcher; and a compressor for recompressing said stretched pulses.
11. An optical combination, comprising; a seed pulse source producing optical pulses with a certain spectral bandwidth; a chirped fiber Bragg grating stretcher system, said fiber Bragg grating stretcher system exhibiting a group delay ripple of less than 10 ps within the spectral bandwidth of said seed pulse source; and an amplifier following said stretcher.

12. A method for designing the dispersion profile of a chirped fiber Bragg grating stretcher to match the dispersion profile of a bulk grating compressor; comprising measuring or calculating the dispersion profile of the bulk grating compressor; producing the chirped fiber Bragg grating stretcher; subsequently measuring group delay variations produced by the chirped fiber Bragg grating stretcher as compared to the bulk grating compressor; and iteratively modifying UV-light exposure of the chirped fiber Bragg grating to minimize the group delay variations inside the chirped fiber Bragg grating.
13. A method for designing the dispersion profile of a chirped fiber Bragg grating stretcher; comprising, producing the chirped fiber Bragg grating stretcher; subsequently measuring group delay variations produced by the chirped fiber Bragg grating stretcher as compared to a designed dispersion profile; and iteratively modifying UV-light exposure of the chirped fiber Bragg grating to minimize the group delay variations inside the chirped fiber Bragg grating.
14. A method for designing the dispersion profile of a chirped fiber Bragg grating stretcher; comprising, producing the chirped fiber Bragg grating stretcher; subsequently measuring group delay variations produced by the chirped fiber Bragg grating stretcher as compared to a designed dispersion profile; iteratively modifying UV-light exposure of the chirped fiber Bragg grating to minimize the group delay variations inside the chirped fiber Bragg grating, and adaptively modifying the dispersion profile of the chirped fiber Bragg grating in use by controllably modifying a refractive index of at least one selectable portion thereof.
15. A chirped pulse amplification system, comprising; a seed pulse source producing short optical pulses; a stretcher for stretching said pulses; and a

plurality of concatenated sections of predominantly polarization maintaining fiber, at least one of which is also an amplifier.

16. A chirped pulse amplification system as claimed in claim 15, further comprising; at least one polarizer between sections of predominantly polarization maintaining fiber.

17. A system as claimed in claim 15, wherein at least one of said predominately polarization maintaining fibers is an air-clad fiber.

18. A system as claimed in claim 17, where polarization maintaining operation of said air-clad fiber is obtained by the incorporation of stress producing regions into said air-clad fiber.

19. A system as claimed in claim 15, wherein at least one of said predominately polarization maintaining fibers is a double or n-tuple clad fiber.

20. A chirped pulse amplification system according to claim 3, wherein said at least one fiber amplifier is pumped by an additional fiber laser or amplifier.

21. A chirped pulse amplification system according to claim 20, where said amplifier is one of an Yb-or Nd fiber amplifier.

22. A chirped pulse amplification system according to claim 20, where said amplifier is core-pumped with another fiber laser or amplifier.

23. A chirped pulse amplification system according to claim 20, where said amplifier is an Yb fiber amplifier core-pumped with a Nd-fiber laser or amplifier.

24. A chirped pulse amplification system comprising, at least one nonlinearly chirped fiber Bragg grating pulse stretcher producing stretched pulses; at least one amplifier following said stretcher, and a pulse compressor for

compressing said stretched pulses, said compressed pulses having an energy >100 nJ.

25. A system as claimed in claim 24 wherein said compressor includes at least one chirped fiber Bragg grating and a bulk grating.
26. A system as claimed in claim 24 wherein the pulse compressor comprises a hollow or photonic bandgap fiber.
27. A system as claimed in claim 26 wherein the hollow or photonic bandgap fiber is engineered to perform complete pulse compression or partial pulse compression.
28. A system as claimed in claim 27, wherein the hollow or photonic bandgap fiber which performs complete or partial pulse compression also acts as power delivery fiber.
29. A chirped pulse amplification system, including a short pulse seed source, a fiber grating pulse stretcher, an adaptive pulse shaper, at least one amplifier and a pulse compressor.
30. A CPA system according to claim 29, where the amplifier is one of a fiber, Raman, parametric, solid-state or diode amplifier.
31. A CPA system according to claim 29, where the adaptive pulse shaper is an adaptive fiber grating based pulse shaper.
32. A CPA system according to claim 29, where the fiber grating pulse stretcher and the adaptive pulse shaper are combined into one integrated fiber grating pulse shaping device.
33. A CPA system according to claim 32, where adaptive pulse shaping in said fiber grating pulse shaper is enabled via modifying a refractive index of at least

one selectable portion of said grating pulse shaper by controlling a temperature of said selectable portion.

34. A CPA system according to claim 32, where adaptive pulse shaping in said fiber grating pulse shaper is enabled via modifying a refractive index of at least one selectable portion of said grating pulse shaper by controlling an internal stress within said selectable portion.

35. A method as claimed in claim 33 wherein a number of said selectable portions is in a range between 4 and 4000.

36. A method as claimed in claim 34 wherein a number of said selectable portions is in a range between 4 and 4000.

37. A method as claimed in claim 35, wherein a number of said selectable portions is in a range between 4 and 400.

38. A method as claimed in claim 36 wherein a number of said selectable portions is in a range between 4 and 400.

39. A chirped pulse amplification system comprising, a nonlinearly chirped fiber Bragg grating pulse stretcher, said fiber Bragg grating pulse stretcher producing stretched pulses longer than 1 ns; at least one amplifier following said stretcher, and a pulse compressor for compressing said stretched pulses by more than a factor of 50, said pulses having an energy of $> 1 \mu\text{J}$. (1 micro J)

40. A chirped pulse amplification system comprising, a nonlinearly chirped fiber Bragg grating pulse stretcher, at least one fiber amplifier following said stretcher and having a substantially step index profile, and a pulse compressor for compressing said stretched pulses.

41. A fiber chirped pulse amplification system according to claim 3, further comprising an adaptively controlled pulse shaper located up-stream of said at least

one amplifier, in order to pre-compensate for self-phase modulation in said at least one amplifier.

42. A method for adaptively modifying the dispersion profile of a chirped fiber Bragg grating, comprising modifying a refractive index of at least one selectable portion of said grating in order to pre-compensate for self-phase modulation in one or more following amplifier stages.

43. A method for pre-compensating for self-phase modulation induced in one or more optical amplifier stages, comprising statically or adaptively modifying the dispersion profile of a chirped fiber Bragg grating optically preceding said one or more amplifier stages.

44. A chirped pulse amplification system comprising, a fiber Bragg grating pulse stretcher, said fiber Bragg grating pulse stretcher producing stretched pulses or pulse trains with a prescribed, but freely selectable amplitude and phase profile, at least one amplifier following said stretcher, and a pulse compressor for compressing said stretched pulses, thereby producing output pulses or output pulse trains with a freely selectable amplitude profile.

45. A chirped pulse amplification system according to claim 36, where said freely selectable amplitude profile is produced at a target material, the optical beam path between said bulk compressor and said target material further containing optical material other than air, comprising either of bulk optical materials and or optical delivery fibers.

46. A chirped pulse amplification system according to claim 36, where said output pulse or output pulse trains are used for micro-structuring or micro-machining of a target material and where said amplitude profile is optimized for the micro-structuring properties of said target material.

47. A chirped pulse amplification systems according to claim 36, where said freely selectable amplitude profile generated by said pulse stretcher is used to counteract gain-narrowing in the at least one amplifier down-stream from said pulse stretcher, such that the amplified pulse width after compression in said pulse compressor is minimized.

48. A chirped pulse amplification system, comprising, a fiber Bragg grating pulse stretcher system including a plurality of fiber Bragg gratings, each of which is designed to stretch a separate spectral component of an input pulse; at least one amplifier following said stretcher system, and a pulse compressor system for compressing and reconstructing said stretched pulses by incoherent addition.

49. A system as claimed in claim 40 wherein said compressor system comprises a series of bulk compressors spaced so as to temporally reconstruct said input pulse.

50. A system as claimed in claim 40 wherein said compressor system comprises one or more bulk compressors spaced so as to output temporally separated portions of said input pulse.